EXHIBIT F

US009507976B2

(12) **United States Patent**
Smith et al.

(10) **Patent No.: US 9,507,976 B2**
(45) **Date of Patent: Nov. 29, 2016**

(54) **ENCODED INFORMATION READING TERMINAL WITH ITEM LOCATE FUNCTIONALITY**

(75) Inventors: **Taylor Smith**, Charlotte, NC (US); **Huyu Qu**, San Jose, CA (US)

(73) Assignee: **METROLOGIC INSTRUMENTS, INC.**, Blackwood, NJ (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 213 days.

(21) Appl. No.: **13/214,512**

(22) Filed: **Aug. 22, 2011**

(65) **Prior Publication Data**

US 2013/0049962 A1 Feb. 28, 2013

(51) **Int. Cl.**

G06K 7/00	(2006.01)
G06K 7/10	(2006.01)
G06Q 10/08	(2012.01)
G06K 19/07	(2006.01)
G08B 13/24	(2006.01)
G06K 17/00	(2006.01)
H01Q 15/00	(2006.01)

(Continued)

(52) **U.S. Cl.**

CPC ***G06K 7/10079*** (2013.01); ***G06K 7/0008*** (2013.01); ***G06K 17/00*** (2013.01); ***G06K 19/0723*** (2013.01); ***G06Q 10/08*** (2013.01); ***G06Q 10/087*** (2013.01); ***G08B 13/2462*** (2013.01); ***H01Q 1/243*** (2013.01); ***H01Q 1/38*** (2013.01); ***H01Q 15/0086*** (2013.01); ***H01Q 21/08*** (2013.01)

(58) **Field of Classification Search**

CPC G06K 7/0008; G06K 19/0723; G06Q 10/08; G06Q 10/087; G08B 13/2462

USPC 235/380, 385, 492; 340/10.1, 10.3, 340/10.4, 10.51, 10.6, 572.1, 572.4; 455/415, 456.1; 705/17; 706/46; 446/297

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,231,273	A *	7/1993	Caswell et al.	235/385
5,589,844	A *	12/1996	Belcher et al.	343/860

(Continued)

FOREIGN PATENT DOCUMENTS

WO	01/52179	A2	7/2001
WO	2009/064926	A1	5/2009

OTHER PUBLICATIONS

EPCGLOBAL Inc., EPC Radio-Frequency Identity Protocols Class-1 Generation-2 UHF RFID Protocol for Communications at 860 MHz-960 MHz, Version 1.0.9, Jan. 31, 2005, pp. 1-94.

(Continued)

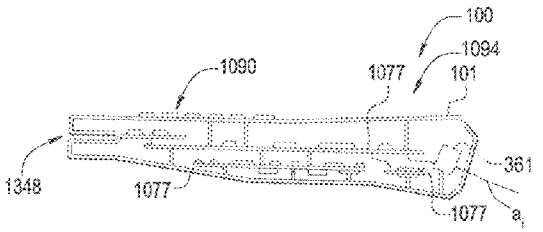
Primary Examiner — Andrew Bee

(74) *Attorney, Agent, or Firm* — Oliff PLC; R. Brian Drozd

(57) **ABSTRACT**

An encoded information reading terminal can comprise a microprocessor, a memory communicatively coupled to the microprocessor, a communication interface, and an RFID reading device configured to output raw message data comprising an encoded message and/or output decoded message data corresponding to an encoded message. The EIR terminal can be configured, responsive to receiving one or more target item identifiers, to attempt to locate at least one RFID tag transmitting an encoded representation of a binary string, at least part of which is equal to at least part one of the specified one or more target item identifiers. The EIR terminal can be further configured, responsive to successfully locating at least one RFID tag, to notify a user via a visual message and/or an audible message.

19 Claims, 6 Drawing Sheets



(51) **Int. Cl.**

H01Q 1/24	(2006.01)
H01Q 1/38	(2006.01)
H01Q 21/08	(2006.01)

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,786,764	A *	7/1998	Engellenner	340/572.4
7,190,257	B2 *	3/2007	Maltseff et al.	340/10.51
7,786,844	B2	8/2010	Ehrman et al.	
7,812,725	B2	10/2010	Bolander et al.	
7,839,289	B2	11/2010	Chung et al.	
7,844,505	B1	11/2010	Arneson et al.	
7,859,411	B2	12/2010	Chakraborty	
7,868,760	B2	1/2011	Smith et al.	
7,907,053	B2	3/2011	Wildman et al.	
7,909,248	B1 *	3/2011	Goncalves	G07G 1/0063 235/375
7,916,023	B2	3/2011	Rado	
7,916,025	B2	3/2011	Locker et al.	
7,916,026	B2	3/2011	Johnson et al.	
7,932,809	B2	4/2011	Nair et al.	
7,986,227	B2	7/2011	Yankelevitz et al.	
7,986,239	B2	7/2011	Chang	
8,258,956	B1 *	9/2012	Kuzma et al.	340/572.1
8,287,327	B1 *	10/2012	Ghaly	446/297
2001/0000958	A1 *	5/2001	Ulrich	G06K 17/0022 340/539.13
2005/0285742	A1 *	12/2005	Charych et al.	340/572.1
2006/0131377	A1 *	6/2006	Zimmerman	235/375
2007/0017983	A1 *	1/2007	Frank et al.	235/385
2007/0138260	A1 *	6/2007	Keys	235/380
2008/0001749	A1 *	1/2008	Fein et al.	340/572.1
2008/0102805	A1 *	5/2008	Balia et al.	455/415
2008/0278370	A1 *	11/2008	Lachner et al.	342/200
2009/0024550	A1 *	1/2009	Wynn et al.	706/46
2009/0224923	A1 *	9/2009	Abraham et al.	340/572.1
2010/0013603	A1 *	1/2010	Chatani et al.	340/10.6
2010/0019035	A1 *	1/2010	Larson et al.	235/385
2010/0060544	A1 *	3/2010	Penev et al.	343/876
2010/0194604	A1	8/2010	Ehrman et al.	
2010/0201520	A1	8/2010	Stern et al.	
2010/0207738	A1 *	8/2010	Bloy	340/10.3
2010/0214067	A1	8/2010	Mo et al.	
2010/0231410	A1	9/2010	Seisenberger et al.	
2010/0276498	A1 *	11/2010	Rofougaran	235/492
2010/0294840	A1	11/2010	Barry	
2010/0295682	A1	11/2010	August et al.	
2010/0295943	A1	11/2010	Cha et al.	
2010/0328073	A1 *	12/2010	Nikitin et al.	340/572.1
2011/0012775	A1	1/2011	Richards et al.	
2011/0032081	A1	2/2011	Wild	
2011/0050397	A1	3/2011	Cova	
2011/0050423	A1	3/2011	Cova et al.	
2011/0068906	A1	3/2011	Shafer et al.	
2011/0068921	A1	3/2011	Shafer	
2011/0090057	A1 *	4/2011	Kosecki et al.	340/10.1
2011/0095885	A9	4/2011	Nielsen et al.	
2011/0109434	A1	5/2011	Hadsall, Sr.	
2011/0109442	A1	5/2011	Pavlov et al.	
2011/0130085	A1	6/2011	Bellows et al.	
2011/0148589	A1	6/2011	Johnson et al.	
2011/0148591	A1	6/2011	Reynolds et al.	
2011/0163857	A1	7/2011	August et al.	
2011/0163882	A1	7/2011	August et al.	
2011/0163916	A1	7/2011	Bamidele	
2011/0169657	A1	7/2011	August et al.	
2011/0183688	A1 *	7/2011	Dietrich et al.	455/456.1
2011/0309136	A1 *	12/2011	Katsakhyan	G10H 1/26 235/375
2012/0075076	A1 *	3/2012	Wang	340/10.4
2012/0092134	A1 *	4/2012	Stern et al.	340/10.1
2012/0193411	A1 *	8/2012	Smith	235/379
2012/0206238	A1 *	8/2012	Lavedas	340/10.1
2012/0313757	A1 *	12/2012	Volpi et al.	340/10.1
2013/0043309	A1 *	2/2013	Qu	G06K 19/07749 235/440
2013/0043981	A1 *	2/2013	Wang et al.	340/10.1
2013/0054390	A1 *	2/2013	Kerchner et al.	705/17

OTHER PUBLICATIONS

Jan. 23, 2013 European Search Report in European Application No. 12181099.8.

Feb. 8, 2013 Communication pursuant to Article 94(3) EPC in European Application No. 12181099.8.

Feb. 10, 2015 Search Report issued in European Application No. 14190366.6.

Mar. 1, 2016 Office Action issued in European Patent Application No. 14 190 366.6.

* cited by examiner

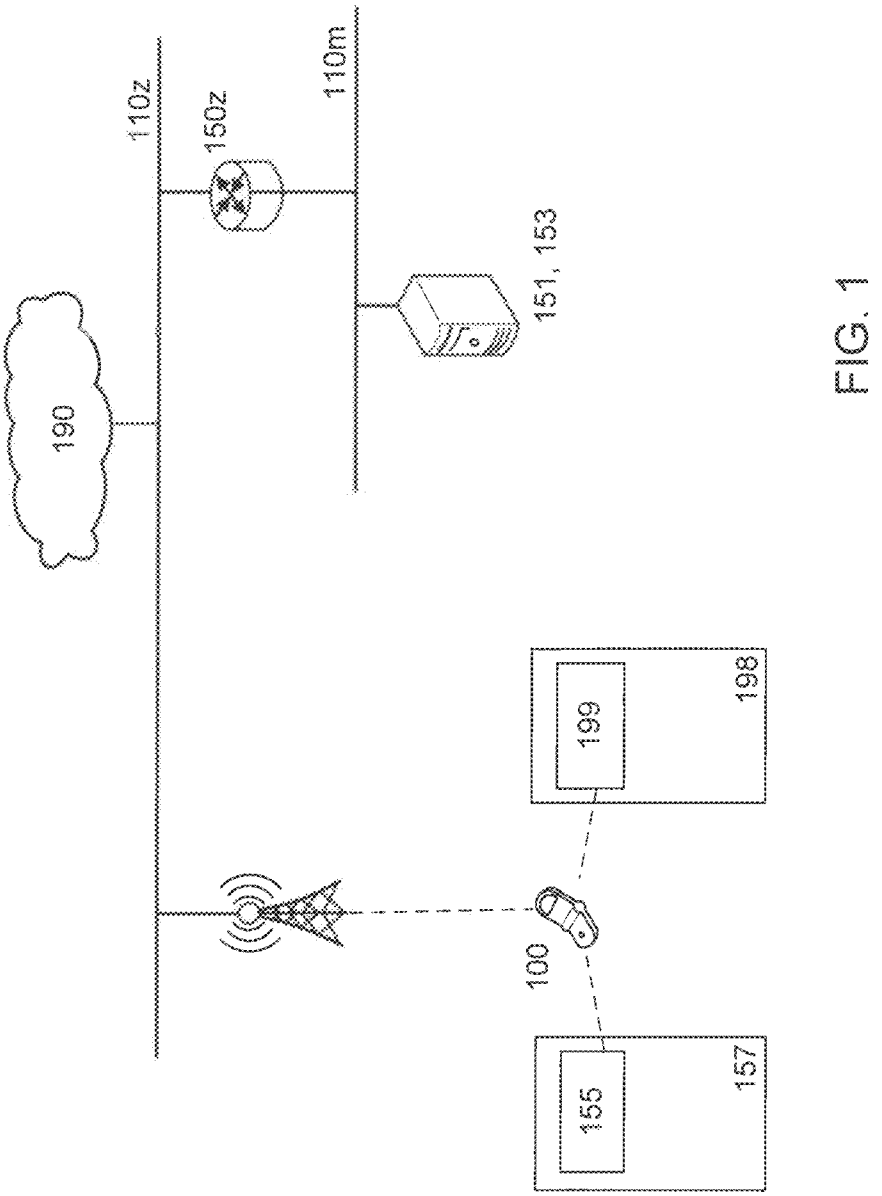


FIG. 1

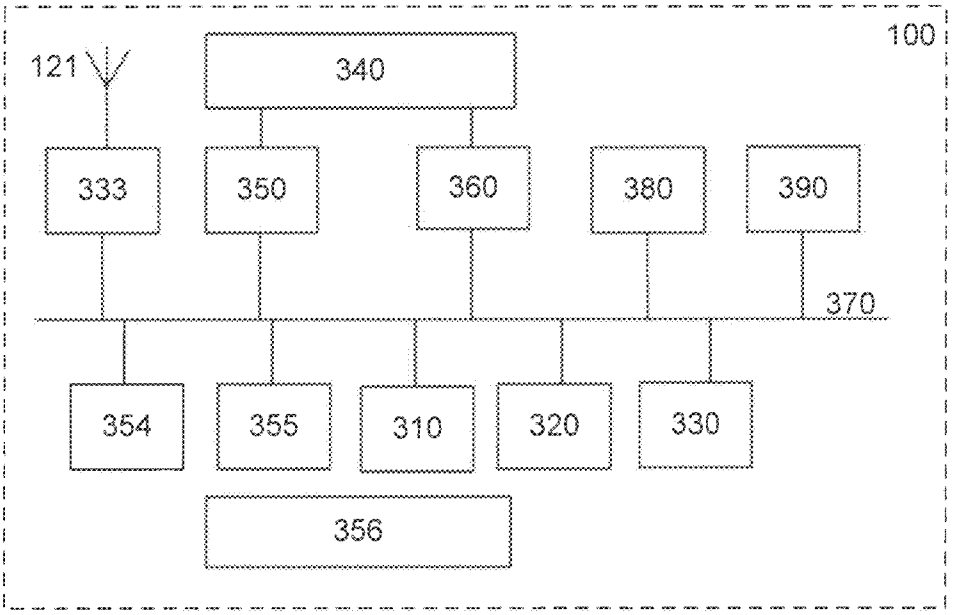


FIG. 2

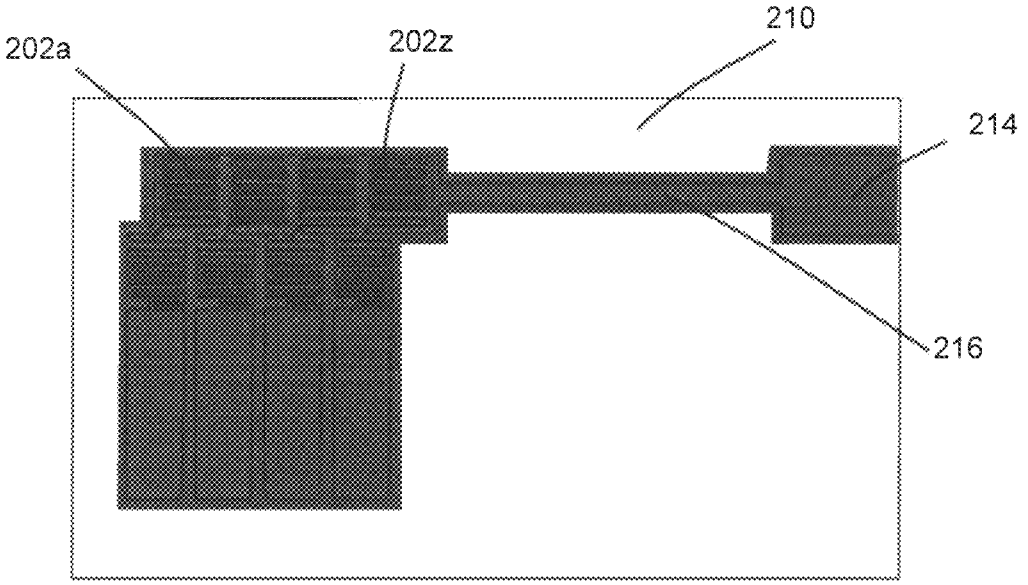


FIG. 3a

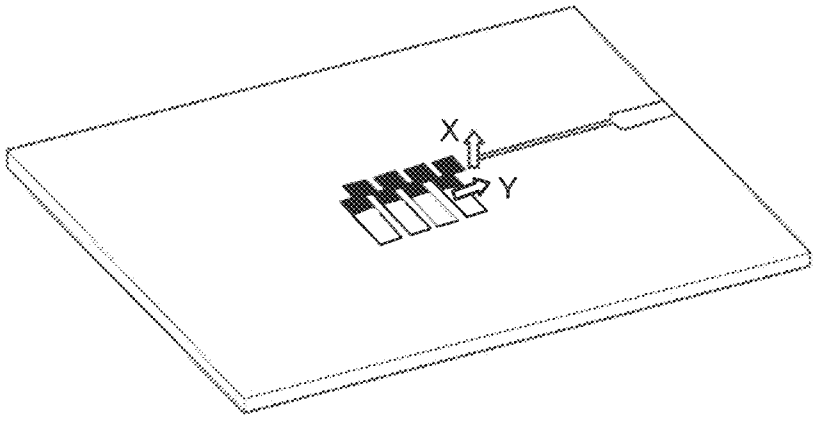


FIG. 3b

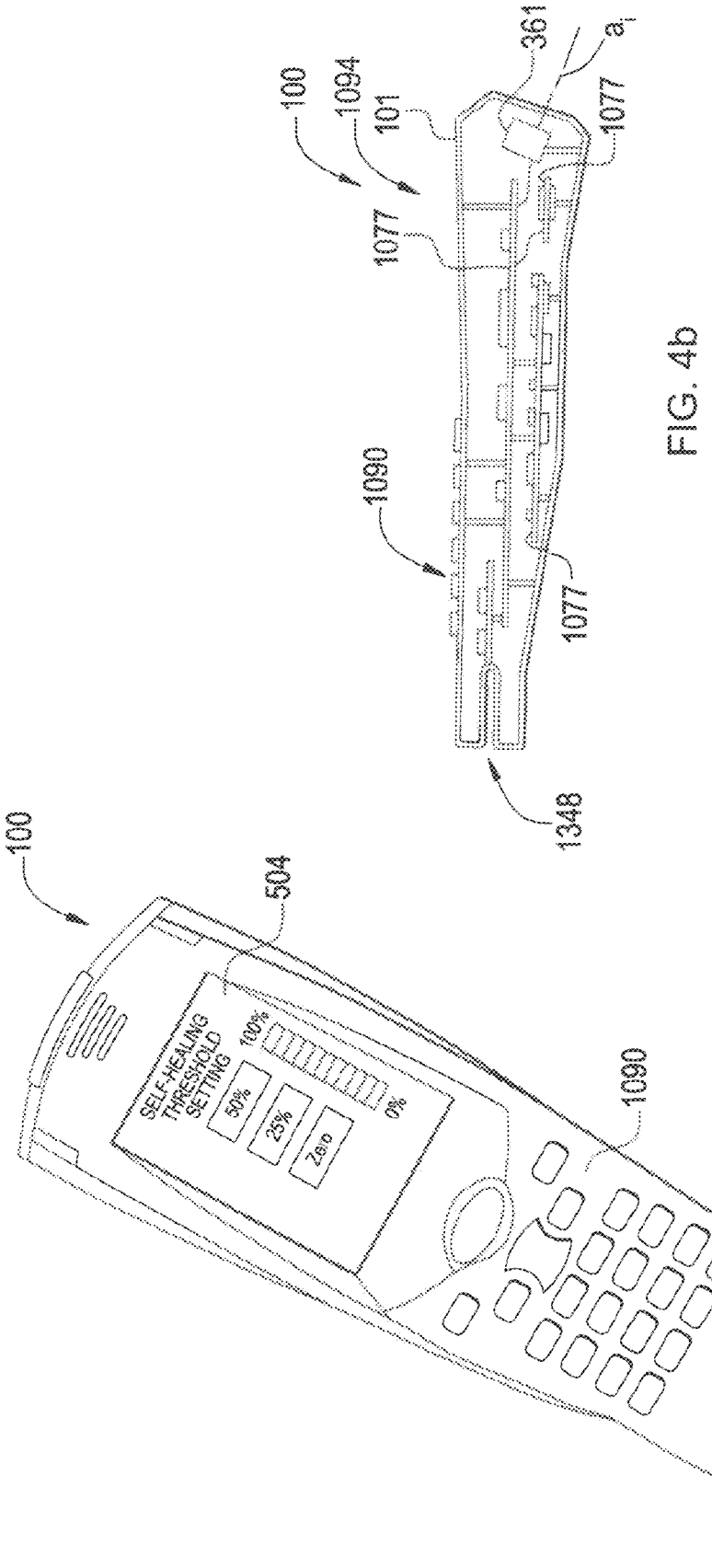

100
504
SELF-HEALING THRESHOLD SETTING
100%
50%
25%
Zero
0%
1090
101
1348
100
1094
101
361
a_1
1077
1077
1090
1077
1348

FIG. 4a

FIG. 4b

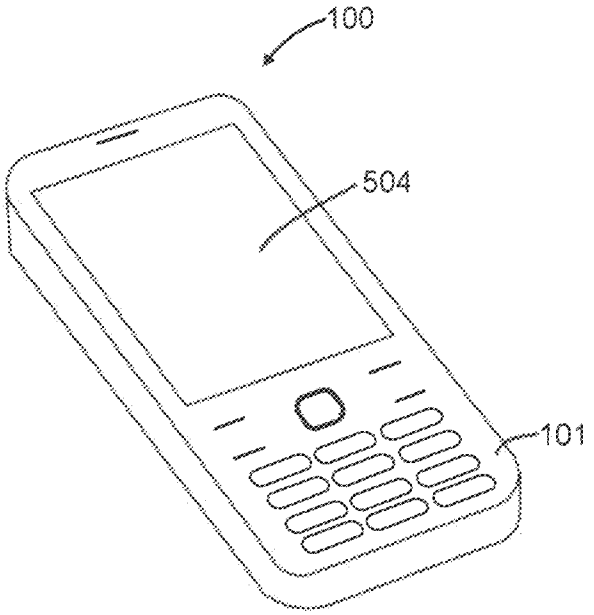


FIG. 5

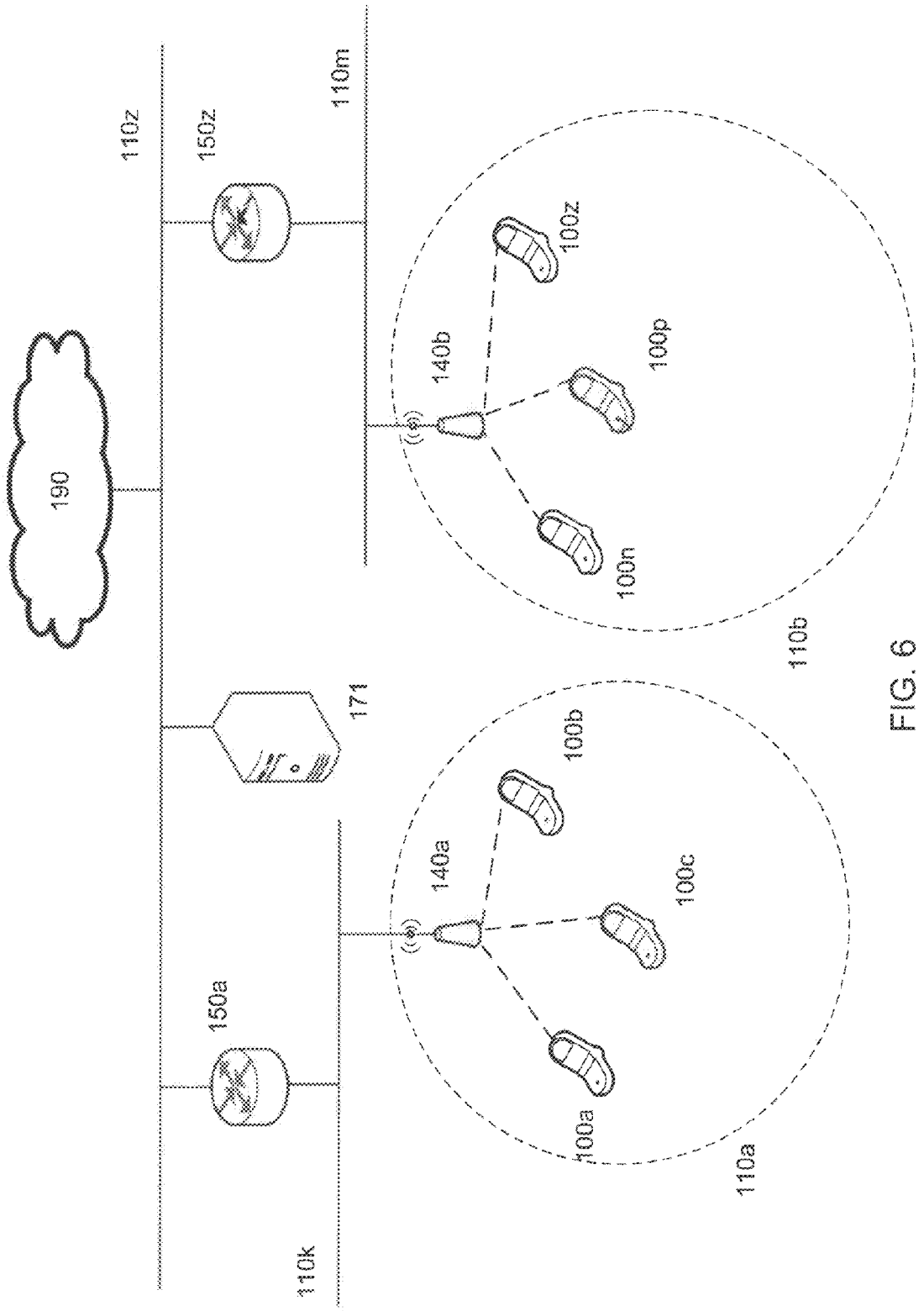

110z
150z
110m
190
171
150a
110k
140b
100z
100p
100n
110b
140a
100b
100c
100a
110a

FIG. 6

ENCODED INFORMATION READING TERMINAL WITH ITEM LOCATE FUNCTIONALITY

FIELD OF THE INVENTION

The invention is generally related to encoded information reading (EIR) terminals and is specifically related to EIR terminals equipped with RFID reading devices.

BACKGROUND OF THE INVENTION

Radio frequency identification (RFID) methods are widely used in a number of applications, including smart cards, item tracking in manufacturing and retail, etc. An RFID tag can be attached, e.g., to a retail item. An EIR terminal can be equipped with an RFID reader to read and/or modify the memory of an RFID tag attached to a retail item.

SUMMARY OF THE INVENTION

In one embodiment, there is provided an encoded information reading (EIR) terminal comprising a microprocessor, a memory communicatively coupled to the microprocessor, a communication interface, and an RFID reading device configured to output raw message data comprising an encoded message and/or output decoded message data corresponding to an encoded message. The EIR terminal can be configured, responsive to receiving one or more target item identifiers, to attempt to locate at least one RFID tag transmitting an encoded representation of a binary string, at least part of which is equal to at least part one of the specified one or more target item identifiers. The EIR terminal can be further configured, responsive to successfully locating at least one RFID tag, to notify the user via a visual message and/or an audible message.

BRIEF DESCRIPTION OF THE DRAWINGS

For the purpose of illustrating the invention, the drawings show aspects of one or more embodiments of the invention. However, it should be understood that the present invention is not limited to the precise arrangements and instrumentalities shown in the drawings, wherein:

FIG. **1** illustrates use case scenario of an EIR terminal equipped with item locate functionality;

FIG. **2** depicts a component level diagram of one embodiment of an EIR terminal equipped with item locate functionality;

FIGS. **3***a*-**3***b* illustrate various embodiments of multiple cell metamaterial (MTM) antennas suitable for an EIR terminal equipped with item locate functionality;

FIGS. **4***a*-**4***b* and **5** illustrate various embodiments of hand held EIR terminal housings;

FIG. **6** depicts a network-level layout of a data collection system utilizing EIR terminals equipped with item locate functionality.

The drawings are not necessarily to scale, emphasis instead generally being placed upon illustrating the principles of the invention. In the drawings, like numerals are used to indicate like parts throughout the various views.

DETAILED DESCRIPTION OF THE INVENTION

In one embodiment, there is provided an encoded information reading (EIR) terminal comprising a radio frequency identifier (RFID) reading device. The EIR terminal can be configured to read RFID tags containing decoded messages. In one embodiment, the RFID terminal can be configured to read an RFID tag containing an encoded message and output raw message data containing the encoded message. In another embodiment, the RFID terminal can be configured to read an RFID tag containing an encoded message and output decoded message data corresponding to the encoded message.

Various embodiments of EIR terminals can be used in a numerous applications, including but not limited to, authentication and access control systems (for example, using smart cards), item tracking in manufacturing and retail, etc. A smart card is an identification card (e.g., a credit card, a pass card) which does not need to be swiped or otherwise physically contacted by a card reader. This capability can be implemented by placing an RFID tag in the card. Item tracking can be implemented by placing an RFID tag on each individual item. Item tracking with RFID tags can be used in loss prevention systems by placing an RFID tag into merchandise items and placing sensors at exit points. If an exit sensor detects a tagged item with a tag, which was not deactivated at the checkout, an alarm can go off. In retail, item tracking with RFID tags can be used in conjunction with other technologies such as bar code scanning and payment terminals.

Of course, devices that read bar codes, read RFID, or read cards bearing encoded information may read more than one of these categories while remaining within the scope of this disclosure. For example, a device that reads bar codes may include a card reader, and/or RFID reader; a device that reads RFID may also be able to read bar codes and/or cards; and a device that reads cards may be able to also read bar codes and/or RFID. For further clarity, it is not necessary that a device's primary function involve any of these functions in order to be considered such a device; for example, a cellular telephone, smartphone, or PDA that is capable of reading bar codes is referred to as EIR terminal throughout this disclosure.

RFID technology can advantageously be used to locate a tagged item. In one example, illustrated in FIG. **1**, a retail customer can use his or her mobile communication device **100** (e.g., a smartphone) to search for an item identifier in a database **151** residing on a remote server **153**, and then using the smartphone's built-in RFID reader, locate on the sales floor the item of interest **198** with RFID tag **199** attached to it.

In another example, a retail customer looking to find a particular product, can scan a bar code tag or read RFID tag **155** of any similarly looking product **157** using his or her mobile communication device **100** (e.g., a smartphone). Smartphone **100** can be programmed, responsive to scanning a product tag, to retrieve the product characteristics from an external database **151** that can be provided by the retailer, the product manufacturer, or by a third party. Smartphone **100** can further be programmed to display the retrieved product characteristics and to accept user's input editing the product characteristics. Smartphone **100** can further be programmed, responsive to accepting the user edited product characteristics, to retrieve the product identifier, optionally accompanied by the product availability and pricing, from external database **151**. Smartphone **100** can further be programmed, responsive to retrieving the product identifier, to either locate the desired product **198** within the RFID communication range or display a failure message.

In another example, a retail store sales associate can use his or her portable data terminal to search for an item identifier in a store database, and then to locate the item on the sales floor or in a stockroom using the terminal's built-in RFID reader. In a yet another example, a warehouse worker can use his or her portable data terminal to receive an item identifier from a workflow process running on a local or remote server computer, and then to locate the item in the warehouse using the terminal's built-in RFID reader. In a yet another example, an airline passenger can receive an SMS or an MMS containing a tag identifier of an RFID tag attached to his or her luggage, and then to locate the luggage on or around a luggage distributing belt using the RFID reader built-in into his or her smartphone. In a yet another example, luggage tag identifiers can be provided to an airline passenger as part of an electronic boarding pass transferred to the passenger's mobile phone, e.g., via SMS or MMS.

Component-level diagram of one embodiment of EIR terminal **100** is now being described with references to FIG. **2**. EIR terminal **100** can comprise at least one microprocessor **310** and a memory **320**, both coupled to the system bus **370**. Microprocessor **310** can be provided by a general purpose microprocessor or by a specialized microprocessor (e.g., an ASIC). In one embodiment, EIR terminal **100** can comprise a single microprocessor which can be referred to as a central processing unit (CPU). In another embodiment, EIR terminal **100** can comprise two or more microprocessors, for example a CPU and a specialized microprocessor (e.g., an ASIC). In one embodiment, memory **320** can be provided by RAM, ROM, EPROM, and/or SIM card-based memory.

EIR terminal **100** can further comprise one or more EIR devices **330**, including a bar code reading device, an RFID reading device, and a card reading device, also coupled to system bus **370**. In one embodiment, an EIR reading device can be capable of outputting decoded message data corresponding to an encoded message. In another embodiment, the EIR reading device can output raw message data comprising an encoded message, e.g., raw image data or raw RFID data.

EIR terminal **100** can further comprise a keyboard interface **354** and a display adapter **355**, both also coupled to system bus **370**. EIR terminal **100** can further comprise a battery **356**. In one embodiment, the EIR terminal **100** can further comprise an accelerometer **357**. In one embodiment, the EIR terminal **100** can further comprise a GPS receiver **380**. In one embodiment, the EIR terminal **100** can further comprise at least one connector **390** configured to receive a subscriber identity module (SIM) card.

As noted herein supra, in one embodiment, EIR terminal **100** can comprise an RFID reading device **333**. In a further aspect, the RFID reading device can comprise an antenna **121**. In one embodiment, antenna **121** can be provided by a single-cell or multiple-cell transmission line MTM antenna shown in FIGS. **3***a* (top view) and **3***b* (3D view). Antenna **121** can comprise one or more conductive cell patches **202***a*-**202***z* that can be mounted on a dielectric substrate, provided, for example, by a printed circuit board (PCB) **210**. Conductive cell patches **202***a*-**202***z* can be spatially separated so that capacitive couplings between adjacent cell patches can be created. Antenna **121** can be designed to include a left-hand capacitance of a right-hand inductance. Also disposed on the dielectric substrate **210** can be a feed pad **214** that can be provided, e.g., by a metallic plate and can be connected to a conductive feed line **216**. Conductive feed line **216** can be provided, e.g., by metallic a strip. Conductive feed line **216** can be located close but separately from conductive cell patches **202***a*-**202***b*. A skilled artisan would appreciate the fact that MTM antennas having two or more conductive feed lines are within the scope of this disclosure. A ground plane can be provided by a metallic layer disposed on the bottom side of PCB **210** (not shown in FIG. **3***a*) or/and on the top side of PCB **210**. In one embodiment, each cell patch can be connected to the ground plane via a zigzag line to create a left-hand inductance. In another embodiment, each cell patch can be connected to the ground plane by a via.

The components of EIR terminal **100** can be incorporated into a variety of different housings of various forms factors. As indicated by the embodiment of FIGS. **4***a* and **4***b*, the components of FIG. **2** can be incorporated into a hand held housing **101**. EIR terminal **100** of FIGS. **4***a* and **4***b* is in the form factor of a hand held portable data terminal. EIR terminal **100** as shown in FIGS. **4***a* and **4***b* can include a keyboard **1090**, a display **504** having an associated touch screen overlay, a card reader **1348**, and an imaging module **361**. As indicated by the side view of FIG. **4***b*, the components of the block diagram of FIG. **2** can be supported within housing **101** on a plurality of circuit boards **1077**. In one embodiment, schematically shown in FIG. **5**, EIR terminal **100** can be provided by a smartphone. Smartphone **100** can comprise a hand held housing **101**, a display **504** having an associated touch screen overlay, and an imaging module (not shown in FIG. **5**). A skilled artisan would appreciate the fact that other housings and form factors of EIR terminal **100** are within the scope of this disclosure.

In another aspect, EIR terminal **100** can be incorporated in a data collection system. The data collection system, schematically shown in FIG. **6**, can include a plurality of EIR terminals **100***a*-**100***z* in communication with a plurality of interconnected networks **110***a*-**110***z*. In one aspect, the plurality of networks **110***a*-**110***z* can include at least one wireless communication network. In a further aspect, EIR terminal **100** can comprise a communication interface **310** which can be used by the terminal to connect to one or more networks **110***a*-**110***z*. In one embodiment, the communication interface can be provided by a wireless communication interface.

EIR terminal **100** can establish a communication session with external computer **171**. In one embodiment, network frames can be exchanged by the EIR terminal **100** and external computer **171** via one or more routers, base stations, and other infrastructure elements. In another embodiment, external computer **171** can be reachable by the EIR terminal **100** via a local area network (LAN). In a yet another embodiment, external computer **171** can be reachable by EIR terminal **100** via a wide area network (WAN). A skilled artisan would appreciate the fact that other methods of providing interconnectivity between EIR terminal **100***c* and external computer **171** relying upon LANs, WANs, virtual private networks (VPNs), and/or other types of network are within the scope of this disclosure.

In one embodiment, communications between the EIR terminal **100** and external computer **171** can comprise a series of HTTP requests and responses transmitted over one or more TCP connections. In one embodiment, communications between EIR terminal **100***c* and external computer **171** can comprise VoIP traffic transmitted over one or more TCP and/or UDP ports. A skilled artisan would appreciate the fact that using other transport and application level protocols is within the scope of this disclosure.

In one aspect, at least one of the messages transmitted by the EIR terminal can include decoded message data corresponding to, e.g., a bar code label or an RFID label attached

to an item or a product. For example, an EIR terminal can transmit a request to the host computer to retrieve product-related information corresponding to a product identifier encoded by a bar code label attached to the item, or to transmit an item tacking record for an item identified by a bar code label attached to the item.

In one embodiment, EIR terminal can be configured to interrogate RFID tags located within the RFID communications range. Referring again to FIG. **1**, responsive to receiving an interrogation signal transmitted by EIR terminal **100**, RFID tag **199** can respond to EIR terminal **100** by backscatter-modulating the amplitude and/or phase of the RFID carrier. The response signal can contain useful data, e.g., an Electronic Product Code (EPC) identifier, or a tag identifier (TID). In one embodiment, an RFID tag can constantly or periodically transmit a signal irrespectively of receiving a query signal from an RFID reader.

In another aspect, the information in RFID tag **199** can be programmed during the manufacturing process (factory programming, typically producing a read-only RFID tag) or after the manufacturing process has been completed (field programming). In a further aspect, the information in RFID tag **199** can be updated dynamically when the tag is in operation.

In another aspect, the distance at which an RFID tag can be read (the read range) can be affected by a number of factors, including the signal frequency, the antenna gain, antenna radiation pattern, the orientation and polarization of the RFID reading device antenna and the RFID tag antenna. In a further aspect, the signal strength of an RFID signal received by EIR terminal **100** from RFID tag **199**, combined with some other settings and data, such as reader antenna orientation, reader antenna location, RSSI from other readers, etc., can be indicative of the distance range between EIR terminal **100** and RFID tag **199**

In one embodiment, RFID tag **199** can be compliant with Generation 2 UHF Air Interface Protocol Standard commonly known as the "Gen 2" standard, which defines physical and logical requirements for a passive-backscatter, Interrogator-talks-first (ITF) RFID system operating in the 860 MHz-960 MHz frequency range.

In one embodiment, RFID tag **199** can be configured to store an Electronic Product Code (EPC) identifier and tag identifier (TID). In one embodiment, RFID tag **199** can implement a "kill" function that permanently disables the tag. In one embodiment, RFID tag **199** can be configured to support password-protected access control. In one embodiment, RFID tag **199** can comprise a memory, including read-only and programmable (user) memory. In one embodiment, RFID tag **199** can comprise a non-volatile memory which retains information without the need to electrically power the memory device.

In one embodiment, EIR terminal **100** can transmit information to a passive RFID tag **199** by modulating an RF signal in the 860-960 MHz frequency range. RFID **199** tag can receive both information and operating energy from the RF signal transmitted by EIR terminal **100**. EIR terminal **100** can receive information from RFID **199** tag by transmitting a continuous-wave (CW) RF signal to the RFID tag **199**. "Continuous wave" can refer to any waveform transmitted by an RFID reading device and suitable to power a passive RFID tag, e.g., a sinusoid at a given frequency. RFID tag **199** can respond by modulating the reflection coefficient of its antenna, thus backscattering an information signal to the EIR terminal **100**. RFID tag **199** can modulate the reflection coefficient of its antenna only responsive to receiving an RFID signal from EIR terminal **100**.

In a further aspect, EIR terminal **100** can be configured to send information to one or more RFID tags by modulating an RF carrier using double-sideband amplitude shift keying (DSB-ASK), single-sideband amplitude shift keying (DSB-ASK), or phase-reversal amplitude shift-keying (PR-ASK) using a pulse-interval encoding (PIE) format. RFID tag **199** can be configured to receive its operating energy from the same modulated RF carrier.

EIR terminal **100** can be configured to receive information from RFID tag **199** by transmitting an unmodulated RF carrier and listening for a backscatter reply. RFID tag **199** can be configured to transmit information by backscatter-modulating the amplitude and/or phase of the RFID carrier. RFID tag **199** can be configured to encode the backscattered data using, e.g., FMO baseband or Miller modulation of a subcarrier at the data rate. The encoding method to be employed by RFID tag **199** can be selected by EIR terminal **100**.

In another aspect, the communication link between EIR terminal **100** and RFID tag **199** can be half-duplex, meaning that RFID tag **199** is not required to demodulate EIR terminal's commands while backscattering.

In another aspect, RFID tag **199** can have a memory comprising one or more memory banks Each of the memory banks can comprise zero or more memory words. In one embodiment, RFID tag **199** can comprise a reserved memory bank containing a kill password and an access password. In one embodiment, RFID tag **199** can comprise an EPC memory bank containing a code (e.g., an EPC code) identifying the object to which the RFID tag is or will be attached. In one embodiment, RFID tag **199** can comprise a TID memory bank containing a tag identifier, tag mode number, tag-specific data, and/or vendor specific data. In one embodiment, RFID tag **199** can comprise a user memory bank containing user-specific data.

In another aspect, the kill password can be provided by a 32-bit value stored in the reserved memory bank. EIR terminal **100** use the kill password once for a given RFID tag, to permanently disable the tag. RFID tag **199** should not execute the kill operation if its kill password has not been initialized. The access password can be provided by a 32-bit value stored in the reserved memory bank. RFID tag **199** having an initialized (non-zero) access password can require EIR terminal **100** to supply the access password before transitioning to a secured state.

In another aspect, EIR terminal can establish one or more sessions with one or more RFID tags. RFID tag **199** can support at least one session-dependent flag for every session. The session-dependent flag can have two states. RFID tag **199** can invert a session-dependent flag responsive to receiving a command from EIR terminal **100**. Tag resources other than session-dependent flags can be shared among sessions. In another aspect, an RFID tag can support a selected status flag indicating that the tag was selected by EIR terminal **100**.

Referring again to FIG. **1**, EIR terminal **100** can be configured to interrogate RFID tags located within the RFID communications range in order to locate at least one RFID tag transmitting an encoded representation of a binary string, at least part of which is equal to at least part one of the specified one or more target item identifiers.

The target item identifier can be in a form of a product code (e.g., an EPC code) or an RFID tag identifier. A skilled artisan would appreciate the fact that other methods of specifying the target item identifier are within the scope of this disclosure. The target item identifier can be inputted into EIR terminal **100** using numerous methods. In one embodiment, the target item identifier can be scanned using the

terminal's bar code reading device. In another embodiment, the target item identifier can be keyed-in by a user using the terminal's keyboard or virtual keyboard. In a yet another embodiment, EIR terminal **100** can retrieve the target item identifier by querying external database **151** using search terms (e.g., item description) provided by the user. In one embodiment, the external database can return two or more item identifiers satisfying the specified search terms, and EIR terminal **100** can prompt the user to select one or more target item identifiers from the list of identifiers returned by database **151**. In one embodiment, EIR terminal can prompt the user to specify additional search terms and, responsive to receiving the user input, query database **151** using the updated search terms.

In another embodiment, the target item identifier can be specified by a user employing EIR terminal **100** to scan a bar code or an RFID tag of a sample item having at least some similarity with the target item. EIR terminal **100** can be configured, responsive to scanning a bar code or reading an RFID tag, to retrieve corresponding sample item description from external database **151**. The sample item description can comprise one or more sample item characteristics. EIR terminal **100** can be further configured to display at least part of the item description retrieved from database **151** and to accept user input editing the item description (e.g., by modifying one or more sample item characteristics). EIR terminal **100** can be further configured to retrieve the target item identifier satisfying the modified description from external database **151**. In one embodiment, the target item identifier retrieved from external database **151** can be accompanied by auxiliary item information, such as item availability, location, pricing, etc.

In a further aspect, database **151** can reside on external server **153**. In one embodiment, server **153** can be accessed by EIR terminal **100** using the terminal's wireless communication interface. In one embodiment, server **153** can be accessible via the Internet. In another embodiment, server **153** can be accessible via a local network (e.g., a retail store network). A skilled artisan would appreciate the fact that other methods of EIR terminal **100** accessing server **153** are within the scope of this description.

In another embodiment, EIR terminal can be configured to receive the target item identifier via a messaging service, e.g., SMS or MMS. In another embodiment, EIR terminal can be configured to receive the target item identifier via voice command module of the EIR terminal by converting a user voice command into an alphanumeric string containing the target item identifier. A skilled artisan would appreciate the fact that other methods of EIR terminal **100** receiving the target item identifier are within the scope of this disclosure.

As noted herein supra, responsive to receiving the target item identifier, EIR terminal **100** can be configured to interrogate RFID tags located within the RFID communications range in order to locate at least one RFID tag transmitting an encoded representation of a binary string, at least part of which is equal to at least part one of the specified one or more target item identifiers.

Responsive to receiving an interrogation signal transmitted by EIR terminal **100**, RFID tag **199** can transmit a response signal back to EIR terminal **100**. The response signal can contain useful data, e.g., an Electronic Product Code (EPC) identifier, or a tag identifier (TID). The response signal can include a representation of a binary string, at least part of which is equal to at least part one of the specified one or more target item identifiers.

In one embodiment, EIR terminal can be configured to listen to radio signals at one or more pre-defined frequencies before transmitting tag interrogation signals. In one embodiment, RFID tag **199** can constantly or periodically transmit a signal irrespectively of receiving a query signal from an EIR terminal.

In one embodiment, EIR terminal can implement *EPC™ Class-1 Generation-2 UHF RFID Protocol for Communications at 860 MHz-960 MHz* by EPCglobal. EIR terminal **100** can interrogate RFID tags using the commands described herein infra.

Select command can be used by EIR terminal **100** to select a particular RFID tag population for the subsequent inventory round. Select command can be applied successively to select a particular tag population based on user-specified criteria. Select command can include the following parameters:

- Target parameter indicates whether Select command modifies a tag's SL flag or Inventoried flag, and in the latter case it further specifies one of four available sessions (**S0**, . . . , **S3**);
- Action parameter indicates whether matching tags assert or deassert SL flag, or set their Inventoried flag to A or B state; tags conforming to the contents of MemBank, Pointer, Length, and Mask parameters are considered to be matching;
- Mask parameter contains a bit string that a tag should compare to a memory location specified by MemBank, Pointer, and Length parameters;
- MemBank parameter specifies the memory bank to which Mask parameter refers (EPC, TID, or User);
- Pointer parameter specifies a memory start location for Mask;
- Length parameter specifies the number of bits of memory for Mask; if Length is equal to zero, all tags are considered matching.

Inventory command set can be used by EIR terminal **100** to single out one or more individual tags from a group. A tag can maintain up to four simultaneous sessions and a binary Inventoried flag for each session. Inventory command set includes the following commands:

- Query command can be used to initiate and specify an inventory round; it contains a slot counter value (Q=0 to 15) determining the number of slots in the round; the command also includes Sel parameter specifying which tags should respond to the Query.
- QueryAdjust command can be used to adjust the value of the tag's slot counter Q without changing any other parameters;
- QueryRep command can be used to repeat the last Query command;
- Ack command can be used to acknowledge a tag's response;
- Nak command can be used to force a tag to change its state to Arbitrate.

An RFID tag can implement a state machine. Once energized, a tag can change its current state to Ready. A selected tag can, responsive to receiving Query command, select a random integer from the range of $[0; 2^{Q-1}]$. If the value of zero is selected, the tag can transition to Reply state, backscaterring a 16-bit random number. If a non-zero value is selected, the tag can load the selected random integer into its slot counter and change its state to Arbitrate.

Responsive to receiving the tag transmission, EIR terminal can acknowledge it with Ack command containing the same random number. Responsive to receiving Ack command, the tag can change its state to Acknowledged and

backscatter its protocol control (PC) bits, EPC and cyclic redundancy check (CRC) value. Unacknowledged tag can select a new random integer from the range of [0; 2^{Q-1}], load the value into its slot counter, and change its state to Arbitrate. Responsive to receiving QueryAdjust command, a tag in the Arbitrate state should decrement the value of its slot counter and backscatter its protocol control (PC) bits, EPC and CRC value if its slot counter is equal to zero.

Responsive to receiving the tag's transmission of its PC, EPC and 16-bit CRC value, EIR terminal can send a QueryAdjust command causing the tag to invert its Inventoried flag and to transition to Ready state.

Access command set can be used by EIR terminal **100** for communicating with (reading from and writing to) a tag. An individual tag must be uniquely identified prior to access. Access command set includes the following commands:

ReqRn command can be used by EIR terminal **100** to request a handle from a tag; the handle can be used in the subsequent Access command set commands. Responsive to receiving Req_RN commands, a tag returns a 16-bit random integer (handle) and transitions from Acknowledged to Open or Secured state.

Read command can be used by EIR terminal **100** to read tag's Reserved, EPC, TID and User memory;

Write command can be used by EIR terminal **100** to write to tag's Reserved, EPC, TID and User memory;

Kill command can be used by EIR terminal **100** to permanently disable a tag;

Lock command can be used by EIR terminal **100** to lock passwords preventing subsequent read or write operations; lock individual memory banks preventing subsequent write operations; permanently lock the lock status of passwords or memory banks;

Access command can be used by EIR terminal **100** to cause a tag having a non-zero access password to transition from Open to Secured state.

A skilled artisan would appreciate the fact that other methods of interrogating RFID tags by EIR terminal **100** are within the scope of this disclosure.

In a further aspect, EIR terminal **100** can be configured, responsive to successfully locating at least one RFID tag satisfying the search condition (i.e., a tag transmitting an encoded representation of a binary string, at least part of which is equal to at least part one of the specified one or more target item identifiers), to notify the user of EIR terminal **100** of a successful search via a visual message and/or an audible message. A visual Successful Search message can be displayed on display **504** of EIR terminal **100**. An audible Successful Search message can be in a form of a generated voice message or a user-configurable sound.

In one embodiment, EIR terminal can be configured to sense its spatial movement using accelerometer **357**. In one embodiment, EIR terminal **100** can be configured, responsive to sensing a spatial movement of said EIR terminal, to repeatedly attempt to locate at least one RFID tag satisfying the search condition.

In one embodiment, EIR terminal **100** can be configured, responsive to failing to locate within a pre-defined period of time at least one RFID tag satisfying the search condition, to notify the user of EIR terminal **100** of an unsuccessful search attempt via a visual message and/or an audible message. A visual Unsuccessful Search Attempt message can be displayed on display **504** of EIR terminal **100**. In one embodiment, the visual message can indicate an approximate range within which the target item could not be located. An audible successful search message can be in a form of a generated voice message or a user-configurable sound.

In one embodiment, at least part of the above described item locate functionality can be implemented by one or more computer programs executed by microprocessor **310** of FIG. **2**. In one embodiment, at least part of the above described functionality can be implemented by one or more hardware components of EIR terminal **100** of FIG. **2**. In one embodiment, one or more computer programs implementing the above described item locate functionality can be executed by microprocessor **310** of FIG. **2** in parallel with executing other computer programs, including system and/or application computer programs. In one embodiment, one or more computer programs implementing the above described item locate functionality can be executed by two or more microprocessors.

While the present invention has been particularly shown and described with reference to certain exemplary embodiments, it will be understood by one skilled in the art that various changes in detail may be affected therein without departing from the spirit and scope of the invention as defined by claims that can be supported by the written description and drawings. Further, where exemplary embodiments are described with reference to a certain number of elements it will be understood that the exemplary embodiments can be practiced utilizing less than the certain number of elements.

A small sample of systems methods and apparatus that are described herein is as follows:

A1. An encoded information reading (EIR) terminal comprising:

a microprocessor;

a memory communicatively coupled to said microprocessor;

a communication interface;

an RFID reading device configured to perform at least one of: outputting raw message data comprising an encoded message and outputting decoded message data corresponding to an encoded message;

wherein said EIR terminal is configured, responsive to receiving one or more target item identifiers, to attempt to locate at least one RFID tag transmitting an encoded representation of a binary string;

wherein at least part of said binary is equal to at least part of one of said one or more target item identifiers;

wherein said EIR terminal is further configured, responsive to successfully locating said at least one RFID tag, to notify a user of said EIR terminal via at least one of: a visual message and an audible message.

A2. The EIR terminal of A1, wherein said RFID reading device comprises an antenna fabricated of a material having a composite right- and left-handed (CRLH) structure.

A3. The EIR terminal of A1, wherein said target item identifier is provided by at least one of: a product code, an EPC code, a tag identifier, and an alphanumeric string.

A4. The EIR terminal of A1, further comprising a graphical user interface (GUI) configured to receive one or more target item characteristics.

A5. The EIR terminal of A1, further comprising a graphical user interface (GUI) configured to receive one or more target item characteristics;

wherein said EIR terminal is further configured, responsive to receiving said one or more target item characteristics, to receive said target item identifier by querying an external database via said communication interface for at least one item identifier corresponding to an item conforming to said one or more target item characteristics.

A6. The EIR terminal of A1, further configured, responsive to reading by said RFID reading device a decoded message comprising a sample item identifier, to query an external database via said communication interface for a description of a sample item identified by said sample item identifier, said description comprising one or more sample item characteristics;

wherein said EIR terminal is further configured to display via a GUI at least part of said description;

wherein said EIR terminal is further configured to receive a user input specifying one or more target item characteristics by modifying at least one of said one or more sample item characteristics; and

wherein said EIR terminal is further configured, responsive to receiving said user input, to receive said target item identifier by querying an external database via said communication interface for at least one item identifier corresponding to an item conforming to said target item characteristics.

A7. The EIR terminal of claim A1, further configured, responsive to successfully locating said at least one RFID tag, to notify a user of said EIR terminal via at least one of: a visual message indicative of a distance to said at least one RFID tag and an audible message indicative of a distance to said at least one RFID tag.

A8. The EIR terminal of A1, further configured, responsive to sensing a spatial movement of said EIR terminal, to repeatedly attempt to locate said at least one RFID tag.

A9. The EIR terminal of A1, further configured, responsive to failing to locate said at least one RFID tag, to notify a user of said EIR terminal via at least one of: a visual message indicative of a range within which said at least one RFID tag could not be located and an audible message indicative of a range within which said at least one RFID tag could not be located.

A10. The EIR terminal of A1, further comprising an EIR device selected from the group consisting of: a bar code reading device and a card reading device, said EIR device configured to perform at least one of: outputting raw message data comprising an encoded message and outputting decoded message data corresponding to an encoded message.

A11. The EIR terminal of A1, further comprising an EIR device selected from the group consisting of: a bar code reading device and a card reading device, said EIR device configured to perform at least one of: outputting raw message data comprising an encoded message and outputting decoded message data corresponding to an encoded message;

wherein said EIR terminal is further configured to responsive to reading by said EIR device a decoded message comprising an item identifier, to query an external database via said communication interface for a description of an item identified by said item identifier, said description comprising one or more sample item characteristics;

wherein said EIR terminal is further configured to display via a GUI at least part of said description;

wherein said EIR terminal is further configured to receive a user input specifying one or more target item characteristics by modifying at least one of said one or more sample item characteristics; and

wherein said EIR terminal is further configured, responsive to receiving said user input, to receive said target item identifier by querying an external database via said communication interface for at least one item identifier corresponding to an item conforming to said target item characteristics.

A12. The EIR terminal of A1, wherein said EIR terminal is provided by one of: a portable EIR terminal, a bar code reading terminal, a mobile phone, a smart phone, a tablet computer.

While the present invention has been described with reference to a number of specific embodiments, it will be understood that the true spirit and scope of the invention should be determined only with respect to claims that can be supported by the present specification. Further, while in numerous cases herein wherein systems and apparatuses and methods are described as having a certain number of elements it will be understood that such systems, apparatuses and methods can be practiced with fewer than or greater than the mentioned certain number of elements. Also, while a number of particular embodiments have been described, it will be understood that features and aspects that have been described with reference to each particular embodiment can be used with each remaining particularly described embodiment.

We claim:

1. An apparatus comprising:

a communication interface comprising a graphical user interface that:

presents an option to a user to allow the user to select an identifier of a radio frequency identification (RFID) tag that is associated with an item, the RFID tag transmitting an encoded representation of a binary string; and

receives a selection from the user of the RFID tag identifier via the presented option of the graphical user interface; and

an RFID reader that:

transmits an RF interrogation signal, where the RF interrogation signal is configured to activate the RFID tag corresponding to the identifier if the RFID tag is within range of the RF interrogation signal; and

generates a notification indicating the RFID reader received an RFID signal from the RFID tag where at least part of the binary string in the RFID signal is equal to at least part of the selected identifier, thereby indicating that the item associated with the selected identifier is within a range of the RFID reader.

2. The apparatus of claim **1**, wherein said RFID reader comprises an antenna fabricated of a material having a composite right- and left-handed (CRLH) structure.

3. The apparatus of claim **1**, wherein the identifier is provided by at least one of: a product code, an EPC code, a tag identifier, and an alphanumeric string.

4. The apparatus of claim **1**, wherein the graphical user interface (GUI) is configured to receive one or more target item characteristics.

5. The apparatus of claim **1**, wherein the graphical user interface (GUI) is configured to receive one or more target item characteristics;

wherein said apparatus is further configured, responsive to receiving said one or more target item characteristics, to receive said identifier by querying an external database via said communication interface for at least one item identifier corresponding to an item conforming to said one or more target item characteristics.

6. The apparatus of claim **1**, further configured, responsive to reading by said RFID reader a decoded message comprising a sample item identifier, to query an external database via said communication interface for a description

of an object identified by said sample item identifier, said description comprising one or more characteristics of the object;

wherein said apparatus is further configured to display via a GUI at least part of said description;

wherein said apparatus is further configured to receive a user input specifying one or more target item characteristics by modifying at least one of said one or more object characteristics; and

wherein said apparatus is further configured, responsive to receiving said user input, to receive said RFID tag identifier by querying an external database via said communication interface for at least one item identifier corresponding to an item conforming to said one or more target item characteristics.

7. The apparatus of claim **1**, further configured, responsive to successfully locating said RFID tag, to notify a user of said apparatus via at least one of: a visual message indicative of a distance to said RFID tag and an audible message indicative of a distance to said RFID tag.

8. The apparatus of claim **1**, further configured, responsive to sensing a spatial movement of said apparatus, to repeatedly attempt to locate said RFID tag.

9. The apparatus of claim **1**, further configured, responsive to failing to locate said RFID tag, to notify a user of said apparatus via at least one of: a visual message indicative of a range within which said RFID tag could not be located and an audible message indicative of a range within which said RFID tag could not be located.

10. The apparatus of claim **1**, further comprising an EIR device selected from the group consisting of: a bar code reading device and a card reading device, said EIR device configured to perform at least one of: outputting raw message data comprising an encoded message and outputting decoded message data corresponding to an encoded message.

11. The apparatus of claim **1**, wherein said apparatus is provided by one of: a portable RFID terminal, a bar code reading terminal, a mobile phone, a smart phone, or a tablet computer.

12. The apparatus of claim **1**, wherein said apparatus is configured to, responsive to reading a decoded message comprising an item identifier, query an external database via said communication interface for a description of an item identified by said item identifier, said description comprising one or more sample item characteristics;

wherein said apparatus is further configured to display via the graphical user interface at least part of said description;

wherein said apparatus is further configured to receive a user input specifying one or more target item characteristics by modifying at least one of said one or more sample item characteristics; and

wherein said apparatus is further configured, responsive to receiving said user input, to receive an item identifier corresponding to an item conforming to said one or more target item characteristics by querying the external database via said communication interface.

13. The apparatus of claim **1**, wherein the identifier of the RFID tag is selected by scanning a bar code and using the scanned bar code data as the selected identifier.

14. The apparatus of claim **1**, wherein the selected identifier of the RFID tag is compared with the binary string to determine if at least part of the binary string in the RFID signal is equal to at least part of the selected identifier.

15. A method comprising:

displaying a graphical user interface for a user to enter search terms associated with an object;

receiving the search terms from the graphical user interface;

querying, in response to receiving the search terms, a database of target item identifiers;

retrieving, from the database, an identifier in the database satisfying the specified search terms;

transmitting an RF interrogation signal in response to receipt of the identifier, where the RF interrogation signal is configured to activate an RFID tag corresponding to the identifier if the RFID tag is within range of the RF interrogation signal;

interrogating, using an RFID reader, RFID tags in an area corresponding to at least one target item identifier in response to receiving the at least one target item identifier from the database satisfying the specified search terms of the database;

receiving an encoded representation of a data string from at least one RFID tag, wherein at least part of said data string is equal to at least part of the at least one target item identifier; and

generating a notification indicating that the at least part of said data string is equal to the at least part of the at least one target item identifier.

16. The method of claim **15**, further comprising:

responsive to reading a decoded message comprising an item identifier, querying an external database via a communication interface for a description of an item identified by said item identifier, said description comprising one or more sample item characteristics;

displaying via the graphical user interface at least part of said description;

receiving a user input specifying one or more target item characteristics by modifying at least one of said one or more sample item characteristics; and

responsive to receiving said user input, receiving an item identifier corresponding to an item conforming to said one or more target item characteristics by querying the external database via said communication interface.

17. A non-transitory computer readable medium that, when executed by a computer, performs a method, the method comprising:

presenting a communication interface that presents an option to a user to allow the user to select an identifier of a radio frequency identification (RFID) tag that is associated with an item, the RFID tag transmitting an encoded representation of a binary string;

receiving a selection from the user of the RFID tag identifier via the presented option of the communication interface; and

outputting a signal that causes an RFID reader to:

transmit an RF interrogation signal, where the RF interrogation signal is configured to activate the RFID tag corresponding to the identifier if the RFID tag is within range of the RF interrogation signal; and

generate a notification indicating the RFID reader received an RFID signal from the RFID tag where at least part of the binary string in the RFID signal is equal to at least part of the selected identifier, thereby indicating that the item associated with the selected identifier is within a range of the RFID reader.

18. The non-transitory computer readable medium of claim **17**, further comprising:

receiving one or more target item characteristics;

responsive to receiving said one or more target item characteristics, receiving said identifier by querying an external database via said communication interface for at least one item identifier corresponding to an item conforming to said one or more target item characteristics.

19. The non-transitory computer readable medium of claim **17**, further comprising:

responsive to reading a decoded message comprising an item identifier, querying an external database via the communication interface for a description of an item identified by said item identifier, said description comprising one or more sample item characteristics;

displaying via the communication interface at least part of said description;

receiving a user input specifying one or more target item characteristics by modifying at least one of said one or more sample item characteristics; and

responsive to receiving said user input, receiving an item identifier corresponding to an item conforming to said one or more target item characteristics by querying the external database via said communication interface.

* * * * *